CRICULA TRIFENESTRATA (HELFER) (LEPIDOPTERA: SATURNIIDAE) - A SILK PRODUCING WILD INSECT IN INDIA

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Abstract - *Cricula* silkworm (*Cricula trifenestrata* Helfer) is a wild insect present in the northeastern part of India producing golden color fine silk. This silkworm completes its life cycle 4-5 times in a year and is thus termed multivoltine. In certain areas it completes the life cycle twice in a year and is thus termed bivoltine. The *Cricula* silkworm lives on some of the same trees with the commercially exploited 'muga' silkworm, so causes damages to that semi-domesticated silkworm. The *Cricula* feeds on leaves of several plants and migrates from one place to another depending on the availability of food plants. No literature is available on the life cycle, host plant preferences, incidence of the diseases and pests, and the extent of damage it causes to the semi-domesticated muga silkworm (*Antheraea assamensis* Helfer) through acting as a carrier of diseases and destroyer of the host plant. Thus, the present study aimed at recording the detail life cycle of *Cricula* in captivity as well as under natural conditions in order to develop strategies to control the damage it causes to the muga silk industry and also to explore the possibility of utilizing its silk for commercial utilization.

Key words: *Cricula trifenestrata*, Saturniidae, rearing, grainage, disease, pest, utilization, silk, pebrine, flecherie

INTRODUCTION

Seri-biodiversity represents the variability of sericigenous insects and their host plants. In general, sericulture sector is divided broadly into mulberry and vanya sectors. Mulberry silk is produced by *Bombyx mori* and vanya silk is produced by a group of other insects mostly present in the wild. Important among them are eri (*Samia ricini*), muga (*Antheraea assamemsis*), tasar (*Antheraea mylitta*) and oak tasar (*Antheraea proylei*) silkworms. Although, vanya silk constitutes only a small share (<20%) of the total silk production in the world, it has made its own niche in the silk industry through the lustrous and unique fabrics. While the mulberry silkworm, *B. mori* belongs to the family Bombycidae, the vanya silkworms belong to the family Saturniidae, one of the largest groups of Lepidoptera comprising more than 1500 species spread over the world, and a few belong to Lasiocampidae. Among them, about 80 species are known to produce silk which has some economic value (Nässig et al. 1996). According to classification of Lemaire and Minet (1998), it is the largest family of Bombycoidea *sensu stricto*, containing about 1861 species in 162 genera and nine subfamilies. The saturniids, which include some of the largest and most spectacular species of all lepidopterans, are distributed in temperate and tropical conditions and are univoltine to multivoltine, depending on the climatic conditions (Regier et al. 2008). Jolly et al. (1975) reported that many species are present in Asia and Africa that produce wild silk of economic value. Arora and Gupta (1979) estimated as many as 40 species from India, and among them nine species are present in Northeastern India (Thangavelu 1991, Thangavelu et al. 1987). Out of these nine species, the genus *Cricula* Walker (Helfer) is present in the north-eastern part of India and is comprised of three [*drepanoides* is now classified in the genus *Solus*] species viz., *Cricula trifenestrata* (Helfer), *C. andrei* (Jordan 1909) and *C. andamanica* (Veenakumari et al. 1996). Of these, *C. trifenestrata* is widely distributed in the Indian Sub-continent while *C. andrei* (Helfer) mostly present in the Northeast. This silk producing insect feeds on mango (*Mangifera indica* Lin.), som (*Litsea monopetala* Kost.) and cashew plant (*Anacardium occidentale* Lin.) and produces an open ended 'net-like' cocoon of beautiful golden yellow colour. The silk is rich in luster and is used for making spun silk. The present study was undertaken with the objectives of (1) to assess the possibility of utilizing this wild species for commercial exploitation as the silk produced by this insect is lustrous, finer in denier (thickness), the high tensile strength (2) to exploit the genetic hardiness for improving other silk producing insects such as muga (*Antheraea assamensis*) and tasar (*A. myllita*) (3) to reconsider the status of it as a pest of the muga silkworm (4) study the detail life cycle both in captivity and wilderness to understand the impact of domestication.

DISTRIBUTION AND HABITAT OF *CRICULA*

The Indian sub-continent extending from the sub-Himalayan to Sri Lankan region is the natural habitat of several wild silkworms as the North-Eastern region of India appears to be an ideal home for a number of wild sericigenous insects and is the centre of wild silk culture including muga (*Antheraea assamensis* Helfer), eri (*Samia ricini* Jones), oak tasar (*Antheraea proylei* Jolly) and mulberry silk (*Bombyx mori* Linn.) (Peigler & Naumann 2003). The *Cricula* is reported to be distributed from Indian Sub-continent to Philippines, Sulawesi and Java and it possess ample scope for commercial exploitation (Chutia et al. 2010). *Cricula andamanica* is reported from Andaman (Veenakumari et al. 1996). The habitat of *Cricula trifenestrata* ranges from the low land to highland at an altitude of over 2000 m in Meghalaya, Assam, Tripura and West Bengal (Fig. 1).

HOST PLANTS OF *CRICULA*

The *Cricula* is polyphagous in nature and it feeds well on mango (*Mangifera indica* Lin.), som (*Machilus odoratissima* Nees (Watt)), large cardamom (*Amomium subulatum*) and cinnamon (*Cinnamomum zeylanicum*). It has also been reported from West Bengal in India feeding on cashew (*Anacardium occidentale*) and termed as a sporadic pest (Pal & Medda 2006). It has been reported to cause damage to cashew in isolated trees in certain localities in Rajasthan (Mandal 2000). *Cricula* was also reported to attack litchi (*Litchi chinensis* Sonn.), ber

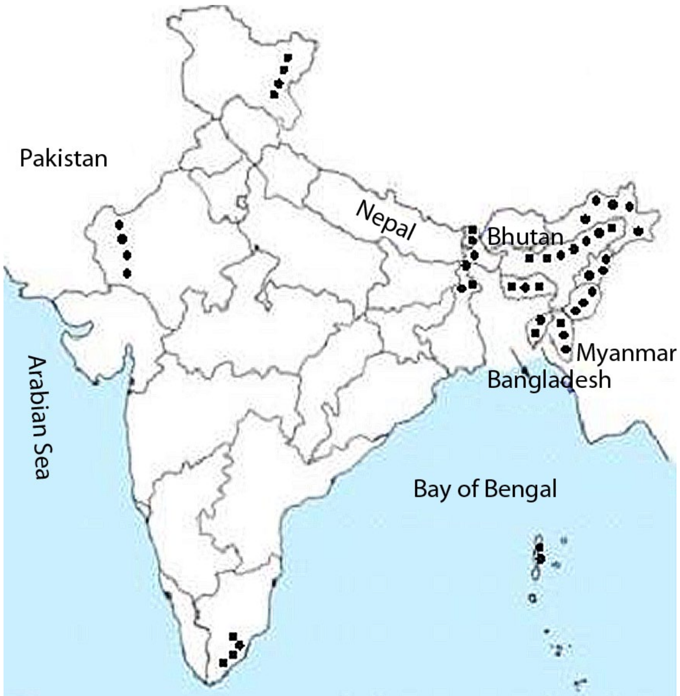

Fig.1. Distribution of *Cricula trifenestrata* in India.

(*Zizyphus jujuba* Mill.) and pepper (*Litsea cubeba* Pers.) (Nair 1975). It is also reported as a pest in tea plantations (Arora & Gupta 1979). More details of the host plants of *Cricula* are presented in Tables 1 and 2.

IN-SITU REARING OF *CRICULA*

The entire life cycle of *Cricula* completes in 45-50 days in summer and 120-125 days in winter. The appearance of adults of *C. trifenestrata* is seasonal from April to November. This saturniid has 5 larval instars. The life cycle in *in-situ* condition of *C. trifenestrata* is described below.

Eggs: The moth lays eggs in a neat row along the outer edge of mango/ som/ cashew leaf where they are easy to see and collect. The eggs resemble beads on a garland and laid in three to four parallel rows. The shape of egg is oval, dorsoventrally flattened and bilaterally symmetrical. At the cephalic end there is a minute hole on the surface of the egg, which is the micropyle. The micropylar end of the egg is flat and the caudal end is narrow. The colour of the egg is ivory white and the size is about 1.20-1.80 mm in length, 1.10-1.90 mm width and the weight varies from 0.004-0.005 mg. The egg number per female varies from 150-250 under *in-situ* conditions. Hatched larvae start feeding on eggshell and disperse in search of food. The duration of egg stage lasts for 10-12 days in summer and 15-20 days in winter. During the rearing season of muga silkworm in April-May, the larva of *C. trifenestrata* was observed on the mango, som, jalpai (Olive), bogori (Ber), cashew, soalu, dighloti, bhemloti and other plants in Assam. Variation in egg size was recorded by other scientists on mango (Ahmed & Alam, 1994, Rono et al. 2008).

Newly hatched larva

The larvae hatch in the morning hours by nibbling through the eggshell. The newly hatched larva is soft and the colour is yellow to yellowish brown, later on turns into yellowish red with prominent dark brown head. After hatching, the larvae congregate on the under surface of the leaves (Fig.3). Later, the larvae disperse and start feeding from the edge of the leaf but are restricted to feeding on leaves of a few neighboring branches. The larva of *C. trifenestrata* has dark grey and blackish transverse bands on the dorsal side and red anal claspers. There is sub-lateral pink stripe and the ventral side is black. There are numerous apparently projected yellow spots on the dorsal side of the body of the caterpillars. The body is covered with numerous white hairs. Each segment is clothed in yellow brown and white hair and the segments are separated by dark brown ring. The thoracic segments are distinct with a pair of legs with densely clothed hairs. The abdomen possesses five pair of pro-legs, present on the third to sixth and tenth abdominal segments. The larva is measured 6.0-12.0 mm in length and 4.0-6.0 mm in breadth. The weight of larva varies from 0.025-0.030 mg. The first moulting starts after 3-4 days feeding in summer season and 6-8 days in winter. The larva enter into the first moult and transforms into second instar larva.

Second instar stage

The second instar larva passes exuviae's of the first instar larva. The body of the larva is clothed with a tuft of long whitish and short blackish hairs arising from tubercles (Fig.3). The general body colour of the larva is combination of red, yellow and black, which is darker than first instars larva. The head is dark brown. The size of the larva is 26.0 -28.0 mm in length and 6.0-7.0 mm in breadth. The weight is approximately 0.04-0.06 mg. The larva feeds for 3-5 days in summer and enters into next moult.

Third instar

The third instar larva is more active, feed voraciously and the size increases quicker than earlier instars. The body colour is reddish yellow with blackish red head (Fig.3). There is a dense growth of whitish hairs arising from mid-dorsal area and the sides of each segment. Legs and pro-legs are brick red in colour. Ventral side of the body is red in each segment. The head and anal claspers turn into reddish colour. The white hair on the body is prominent by length as well. Between each segment numerous white dots are visible. The size of the larva varies from 45.0-50.0 mm in length and 10.0-12.0 mm in width and weighs from 0.25-0.30g. The third instar lasts for 5-7 days in summer and 7-10 days in winter.

Fourth instar

The body colour of fourth instar larva is dark red. The head and anal claspers are also red. The white hairs on the body increase in size. The white dots on the body become more prominent and turn into yellow. The larva eats voraciously and increases in size. The larva size varies from 60.0-70.0 mm in length and 20.0-23.0 mm in breadth and weighs 1.5-2.0 g before entering into the next moult. This stage lasts for 6-9 days in summer and 10-13 days in winter.

Fifth instar

The fifth instar larval stage continues for 10-12 days in summer. The body color is dark brown to orange with pinkish band and yellow spots on dorsal surface (Fig. 4). The full-grown larva was elongate, cylindrical and robust. The thorax and abdomen contain alternative bands of black, yellow and red on the dorsal side in each segment of the body. The fully mature larva attains weight of 4.6-4.8 g, length of 135.0-140.0 mm and breadth of 30-35.0 mm in som plant and 5.10-5.30 g, 137.0-140.0 mm and 32.0-35.0 mm in mango plant. In general, the female larvae are larger and heavier than males. The male and female larvae could be easily distinguished from sexual markings.

Spinning of cocoons

On maturity the larva spins its cocoon on the plant between two to three fresh or dry leaves. The larva passes the last frass before starting the spinning of cocoon to avoid staining of cocoon. The cocoon colour is golden yellow (Fig.3). The female spins larger cocoon than the male. The cocoon size varied from 42.0-45.0 x 12.0-14.0 mm in male and 51.0-55.0 x 16.0-18.0 mm in female, respectively. The single cocoon weight varies from 2.10-2.20 g in female and 1.10-1.20 g in male with some host plants, whereas 1.90-2.00 g and 0.95-1.10 g in female and male if feeding on mango plant. The cocoon peduncle size varies

Fig. 2. *Cricula trifenestrata* (photograph by Kirby Wolfe).

Fig. 3. Immature stages of *Cricula trifenestrata* (photographs by Kirby Wolfe).

from a minimum of 60.0-80.0 mm to a maximum of 100.0-120.0 mm. The cocoon shell weight ranges from 0.08-0.11 g in male and 0.10-0.14 in female. The silk ratio varies from 7.65-9.75 in male and 4.6-7.0 in female. The cocoon size, weight, shell weight and silk filament length vary in different seasons and by the food plants used. The spinning of cocoon takes place in 3 days during summer and in 7 days during winter.

Pupa

The body of pupa is chestnut or dark brown colored. Sex markings are prominent in pupae and they are comparatively easier to use to determine the sex in the pupal stage than in the larvae stage. The female pupa has a fine longitudinal line on the eighth abdominal segment whereas it is absent in males. The pupal stage lasts for 10-14 days in summer. The pupa size varies from 30.0-35.0 x 10.0-12.0 mm in male and 40.0-45.0 x 15.0-17.0 mm in female.

Moth

The moth emerges from the cocoon by making a hole in the anterior end of the cocoon. The emergence of the moths starts at dusk and continues till dawn. The male and female moths exhibit distinct sexual dimorphism (Fig.2). In male moth, the tips of the forewings have sharp curve that is easy to distinguish. The antennae of the male moths are broader than female. The abdomen of the male moth is narrow and small whereas it is broader, larger and swollen in female. The male moths are of three colour forms viz., dark orange, dark ash and dark brown orange, with two pairs of wavy dark to light blue markings both on fore and hind wings. The hind wing line resembles a heartbeat graph. The female moth is also present in five colour forms, i.e., dark orange, dark ash, mixture of ash and orange, ash with silver colour and mixture of orange and silver. There are three prominent transparent eye-spots on the forewing and one on hind wing in both adult moths (Pal & Medda 2006). Rono et al. (2008) reported that male possesses two dark spots on the forewing; the smaller one is anterior to the oblique line, the large one to just below the anterior margin. Head, thorax, abdomen, and appendages of the moth are covered with scales that are like the wing colours. The *Cricula* moth size (length x breadth) was 23.0-25.0 mm x 30.0-34.0 mm in male and 33.0-35.0 mm x 73.0-75.0 mm in female. Similar observation was also reported earlier (Rono et al. 2008). The wingspan in male moth varies from 165.0-190.0 mm and female 180.0 - 195.0 mm. The moth of *Cricula* is comparatively smaller than that of other vanya silk insects.

Coupling and Oviposition

The male moth flies actively after emergence and couples naturally with an available female. After coupling commences, the male moth stops fluttering its wings. The coupling lasts overnight and after decoupling the female moth lays eggs on the edges of leaves of the host plant. The laying of eggs is in the pattern of a beaded garland and two or three parallel lines are made. The number of eggs laid in a day varies from first day to fourth day. The *Cricula* wild silk moth grows in nature under varied temperature and humidity levels and it can survive up to 40ºC and a humidity of 90-95%. The grainage (egg laying) behavior was also observed in captivity to know the behavioral differences of *Cricula* in emergence, mating and egg laying patterns. The egg number under captive conditions varied from 200-250 while the same in natural conditions varied from 150 to 200. The hatching of egg was up to 95% in Assam climatic conditions, but it was poor in Nagaland conditions (Kakati & Chutia 2009, Tikader 2012). The male moth survives for 4-5 days and the female moth for 4-7 days (Rono et al. 2008, Yadav & Kumar 2003).

Cocoon Characteristics

Based on the feeding of *Cricula trifenestrata* in different host plants under similar climatic conditions in different seasons, it is confirmed that female larvae produce bigger cocoons than male counterpart. The shell weight is also higher in females but shell-cocoon ratio is higher in male cocoons. As far as the influence of the host plant is concerned, the SR% is higher in worms fed on cashew followed by mango, black berry, olive, soalu and som (Tikader et al. 2010, 2010a, 2011). The cocoon colour varies depending on the host plant, the quality of leaf and its biochemical constituents.

Disease and Pests of *Cricula*

Cricula trifenestrata Helfer, is susceptible to different pathogens, including viruses, bacteria, fungi and protozoa (Tikader 2011a, c). The major diseases are Pebrine, Grasserie, Flacherie and Muscardine caused respectively by protozoa, virus, bacteria, and fungi. Pebrine, a chronic disease caused by the protozoa *Nosema,* is unique in being transmitted to offspring by transovarial transmission from mother moth and also by secondary infection of larvae through the host plant. The spores of *Nosema* are bright and elongated and slightly bent in the middle as in case of the spores of the *Nosema* infecting muga silkworms, though the spores in *Cricula* are smaller in size. It affects *Cricula* in all seasons but higher in autumn and winter seasons. It attacks all stages of the life cycle of

Cricula silkworm (Thangavelu et al. 1987, 1988).

The flacherie is caused by a virus which is followed by secondary infection of bacteria. This disease is more prevalent in summer when the temperature and humidity are high and the leaf surface contains water from rains or dews. The most visible symptoms are the lethargic and motionless condition of the larvae. The haemolymph of the diseased larvae becomes blackish in color. The muscardine, a fungal disease, is less prevalent and only found in winter season. The infected worms become harder, paler and completely inactive. A white encrustation appears round the body, which becomes laterally compressed, dry, hard and brittle. Later on, they become hard and mummified. The death rate during winter by this disease is 15-20%.

Brachymeria tibialis Walker (Hymenoptera: Chalcididae), a parasitoid attacks the *Cricula* and causes heavy damages to the pupae inside the cocoon, thereby reducing the population of the *Circula* in nature (Tikader 2011b, 2012a). In order to observe the extent of the damages, 50 *Cricula* cocoons each were collected from mango, black berry, cashew and olive and kept for observations on moth emergence. It was found that in some of the cocoons, the parasitoid pierced a small hole to exit the host cocoon. Upon further examination, it was observed that the pupa was eaten partly by the parasitoid and about 10-15 parasotoid insects were present in one infested cocoon. The small insect in the adult form of *Brachymeria* comes out of the cocoons through the small hole. In the population of 200 cocoons, more than 50 cocoons were damaged which is about 25% of the population (Singh & Das 1996).

POST COCOON PARAMETERS

Cricula spins cocoons that are open at both ends, similar to that of Eri (*Samia cynthia ricini*) cocoons. The cocoons are cylindrical in shape and give a mesh-like appearance. The spinnable silk content is comparatively very low (Chutia et al. 2010), hence it is considered to be economically not viable to rear *Cricula* commercially. Nonetheless, the silk is fine and can be used as blending for specific purposes, as for their distinct colour and appearance (Mishra et al. 2011). The cocoon quality differs depending on the host plant. For example, when it feeds on mango, the cocoon is light golden colour and in some it is dark golden colour. The *Cricula* feeding on olive, cashew; ber etc. produces light golden-yellow cocoons. The seasonal effect on the quality and quantity of cocoons is quite apparent. The shape, size, larval development, Shell-Ratio and other cocoon characters also vary, depending on the season (Table 3). The variability in qualitative and quantitative characters of the cocoon depends greatly on the food plants used for feeding (Sharma et al. 1995, Tikader 2011, 2012b).

CRICULA AS A PEST

An insect may be declared harmful when it destroys crops above a threshold level. If the insect grows naturally and unwantedly along with a beneficial insect, it may be termed as a pest. *Cricula trifenestrata* is one of the most destructive pests of mango and destroys 13-51% of its leaves (Ahmad & Alam 1994). It also infests cinnamon, cardamom, cashew, and plantation crops (Ahmad & Ahmad 1991, Das et al. 1999, Yadav & Kumar 2003, Pal & Medda 2006). The population of the insect tends to fluctuate depending on the environmental conditions. Availability of large numbers of alternative host plants facilitates migration of this insect from place to place (Tikader 2011). The population of *Cricula* occasionally increases to a level of causing significant economic injury to the muga silkworm (Sarmah et al. 2010). The population of *Cricula* can be controlled mechanically as egg masses are easily seen on leaves of host plants and there a number of natural predators of this insect such as web weaving and hunting spiders, mantids and several other insect predators which are highly effective in controlling this insect. Outbreaks are rare and are quickly controlled by parasitoids, which achieve a very high rate of parasitization on *Cricula* eggs and pupae. The insect may also be controlled by spraying contact insecticide, cypermethrin (Pal & Medda 2006), but this must be avoided if larvae of muga silkworms are also present. Furthermore, the insect also act as a vector of microsporidians of the muga silkworm. Thus, in spite of producing a lustrous golden silk, *Cricula* is still considered as

Fig. 4. Last instar larvae of *Cricula trifenestrata* (photograph by Kirby Wolfe).

Table 1. New Report of *Cricula trifenestrata* host plants from Boko, Kamrup District, Assam.

Sl	Local/ English name	Scientific name	Family	Distribution
1	Jalpai / Olive	*Elaeocarpus floribundus* Blume	Elaeocarpaceae	India, Bangladesh
2	Bhemloti	*Celastrus monosperma* Roxb.	Celastraceae	Northeast India
3	Baghnala	*Actinodaphne angustifolia* (Nees) Blume	Lauraceae	India
4	Avocado	*Persea Americana* Miller	Lauraceae	America, India
5	Kalojamuk / Blackberry	*Syzygium cumini* (L) Skeels	Myrtaceae	India, Bangladesh
6	Sualu / Soalu	*Litsea monopetala* Roxb.	Lauraceae	Northeast India, Nepal
7	Dighloti	*Litsea salicifolia* Roxb.ex Nees	Lauraceae	Northeast India, Nepal
8	Patihanda	*Actinodaphne obovata* (Nees) Blume	Lauraceae	Northeast India, Bangladesh
9	Panchapa	*Magnolia pterocarpa* The correct name is *M. pterocarpa,* because *sphenocarpa* is an old synonym.	Magnoliaceae	Northeast India, Nepal, Bangladesh, Myanmar

Table 2. List of host plants used as feed of *Cricula trifenestrata.*

Sl	Local / English name	Scientific name	Family	Distribution
1	Kaju badam / Cashew	*Anacardium occidentale* Linn.	Anacardiaceae	Brazil, India, Indonesia, Vietnam
2	Aam /Mango	*Mangifera indica* Linn.	Anacardiaceae	India, China, Pakistan Bangladesh
3	Plum	*Spondias cytherea* Sonnerat	Anacardiaceae	India, Thailand
4	Kumbhi	*Careya arborea* Roxb.	Lecythidaceae	India
5	Bishop wood	*Bischofia trifoliata* Roxb.	Euphorbiaceous	India
6	Canarium nut	*Canarium harveyi* Seem	Burceraceae	India
7	Bunj / Oak	*Quercus serrata* Thungberg ex Murray	Fagaceae	India, Nepal, Bhutan
8	Gansarai	*Cinnamomum glanduliferum* (Wall.) Meissner	Lauraceae	Northeast India
9	Gandhsarai	*Cinnamomum glaucescens* (Nees) Meissner	Lauraceae	Northeast India
10	Dalchini/ Darucini	*Cinnamomum zeylanicum* Blume	Lauraceae	South East Asia, Sri Lanka
11	Som	*Persea bombycina* Kost.	Lauraceae	Northeast India, Nepal
12	Indian ash	*Acrocarpus fraxinifolius* Arn.	Leguminosae	India
13	Bogori / Ber	*Zizyphus jujuba* Mill.	Rhamnaceae	India, China, Afghanistan, Malay
14	Malus (Wall nut)	*Malus floribunda* Siebold ex Vanhoutte	Rosaceae	India, Japan
15	Peach	*Prunus virginiana* (L.) Batsch.	Rosaceae	India, Canada, America
16	Wild pear	*Pyrus communis* Linn.	Rosaceae	China, India, Europe
17	Weeping willow	*Salix babylonica* Linn.	Salicaceae	China, India
18	Lac tree	*Schleichera oleosa* Lour.	Sapindaceae	India, Bangladesh
19	Lichu / Litchi	*Litchi chinensis* Sonn.	Sapindaceae	China, India, Jamaica
20	Pepper	*Piper nigrum* Linn.	Piperaceae	India, Vietnam
21	Bada elaichi	*Elettaria cardamomum* Linn.	Zingiberaceae	India
22	Chah / Tea	*Camellia assamica* J.W.Mast.	Theaceae	India, China, Japan
23	Mountain pepper	*Litsea cubeba* Pers.	Lauraceae	India
24	Himalayan silver	*Betula alnoides* Buch-Ham ex. D.Don	Euphorbiaceace	India, Nepal

Table 3. Performance of *Cricula trifenestrata* when reared on different host plants.

Host plant	Single cocoon Weight (g)		Single shell Weight (g)		Silk ratio (%)		Remarks
	Male	Female	Male	Female	Male	Female	
Som	1.50	2.81	0.113	0.160	7.395	5.717	Silk ratio is observed higher in cashew followed by mango, black berry, olive, soalu and som
Soalu	1.25	2.37	0.096	0.103	7.723	4.354	
Mango	1.25	2.28	0.106	0.136	8.496	6.000	
Black berry	1.30	2.22	0.103	0.120	7.953	5.512	
Cashew	1.20	2.42	0.116	0.153	9.711	6.278	
Olive	1.28	2.21	0.100	0.110	7.830	4.843	
Mean	1.30	2.39	0.106	0.130	8.185	5.451	

Fig. 5. Artifacts produced using silk of *Cricula trifenestrata*: picture frame and earrings made with pieces of cocoons, Yogyakarta, Java, Indonesia. McGuire Center for Lepidoptera and Biodiversity (FLMNH) - donation by Richard S. Peigler. (photographs by Andrei Sourakov).

a pest of muga silkworm, mango tree, cashew nut etc. However, the pest status of it can be converted into a beneficial one, if it is reared for silk on a large scale as it is being done in Indonesia.

UTILIZATION OF *CRICULA*

The naturally coloured materials from the cocoons are now being biochemically analyzed and are found to have several medicinal properties (Kato et al. 2004). The natural color of certain silk fibers are highly valued in silk textiles, for instance, tensan (*Antheraea yamamai*) and muga (*Antheraea assamensis*) silks. *Cricula* golden cocoon is also a unique one. Appreciating the value of the unique golden-colored silk, efforts are being made in several places to culture *Cricula*. Indonesia is an ideal example for it. At present, *Cricula* is considered as a useful insect in Java. For many silk designers, the unique gloss and golden color make it an extremely attractive material. Suvahana is a company which produces accessories and crafts from wild cocoons of *C. trifenestrata* and *Attacus atlas* (Fig. 5). These materials are so special because of their strong character, high quality, water resistant, reshapable for the flower shape, and its golden color is natural and simple. The wild silk is very fine fiber, very porous, soft, cool to wear, heat resistant, non allergenic and anti-bacterial. A thread of *Cricula* from which most of the Rumah Sutera products are made is lighter, more water absorptive than the normal silk and having elegant luster with a soft touch. The moth produces a much higher priced silk than the common silkworm.

The role of the cocoon shell is to protect the moths from a severe environment, for instance high and low temperatures and prevailing humidity as well as various natural enemies. Therefore the cocoon themselves must have protective functions against the environment. The wild silk materials are vastly superior in UV absorption and are able to control UV transmission (Akai 2002). They also have antifungal properties (Kato & Hotta 2000, Kato et al. 2004). Nutritional studies of wild silk powder are suggesting new functions for the wild silk materials such as controlling of cholesterol in the blood, resistance to colon cancer and anti-oxidant activity.

CONSERVATION OF *CRICULA*

A recent survey lists 14 silk-producing Lepidoptera species that can be used by humans from a single province of North-eastern India, namely Nagaland (Kakati & Chutia 2009). However, the natural populations of these species have become scarce and restricted mostly to the interior forests. The diversity present among populations of the same species indicates the capability of the species to adjust to different ecological conditions. It also reveals the genetic potential to interact to different environment elements for surviving and sustaining the life. Parameters like fecundity, hatching percentage and Effective Rate of Rearing (ERR) are good indicators for measuring the survival ability of the species. The salubrious climatic condition (*i.e.* spring and summer) existing in the North-Eastern region of India is suitable for the survival of *Cricula* (Kakati & Chutia 2009). The *Cricula* can survive even at 40°C in summer and the egg/pupa undergoes diapause during winter to avoid the harsh climatic conditions. Since the populations of this wild silk moth are surviving persistently under the regime of the biotic and abiotic ecological factors, their diverse gene pool has the potential to overcome many challenges in nature. Hence, these diverse populations having varied genetic materials need to be conserved for future breeding and genetic studies (Tikader et al. 2011d). Moreover, wild silk moth culture is a tradition of north-east region and used by humans for making clothing as well as a food (eating the pupae). Wild silk moth culture not only has an economic bearing on the local inhabitants of northeastern India but can also help to conserve forest ecosystems. For local people, conservation of wild population of sericigenous moths is much easier than rearing domesticated ones, if it could be carried out *in-situ* (Frankel 1982). The rearing of silkworms in the forest will save the other flora and fauna in the natural balance, yet earning income from the product. So, conservation of sericigenous insect like *Cricula* will help in maintaining a balance of the ecosystem and a source of sustainable livelihood for many ethnic groups.

CONCLUSION

Although *Cricula, an* insect producing a natural golden colour of silk, is considered a pest of som, mango, cardamom, cinnamon, cashew nut and tea, it can be converted into a beneficial insect providing sustainable livelihood to the local population, if it is reared for silk on a large scale, as is being done with other silk-producing insects. Though a sericigenous insect, it is now commercially utilized only in Indonesia where it is used as alternative source of income and has become popular among the farmers. With the wide availability of *Cricula* cocoons, the perception of people has also changed and people have started appreciating and enjoying the beauty of its silk. The silk manufacturers like the cocoon due to its unique gloss and gold colour, which makes an attractive material for fabrics. The cloth materials produced from *Cricula* cocoons are special due to its strong characters such as water resistance and golden color, cool to wear, heat resistance, non allergenic and anti-bacterial properties. The silk thread of *Cricula* products is lighter and more water absorptive than the normal silk, and has an elegant luster with soft touch. Thus, rearing and conservation of *Cricula* are worthy to include in the activities of the sericulture industry. The insect is capable of surviving and producing cocoons and functional adults at 40ºC diurnal temperatures. The genes responsible for such high temperature tolerance need to be elucidated for itheir possible utilization in developing hardy *B. mori* (Tikader et al. 2013), especially in light of the predicted global warming.

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